

TEXTURAL AND GEOCHEMICAL FEATURES ALONG A RESERVOIR-CAP ROCK CONTACT IN THE SACROC UNIT OF WEST TEXAS

Giday WoldeGabriel, Melissa Fittipaldo, Rajesh Pawar,
Marcus Wigand, and J. William Carey

Earth and Environmental Sciences Division
Los Alamos National Laboratory
Los Alamos, NM, 87545 USA

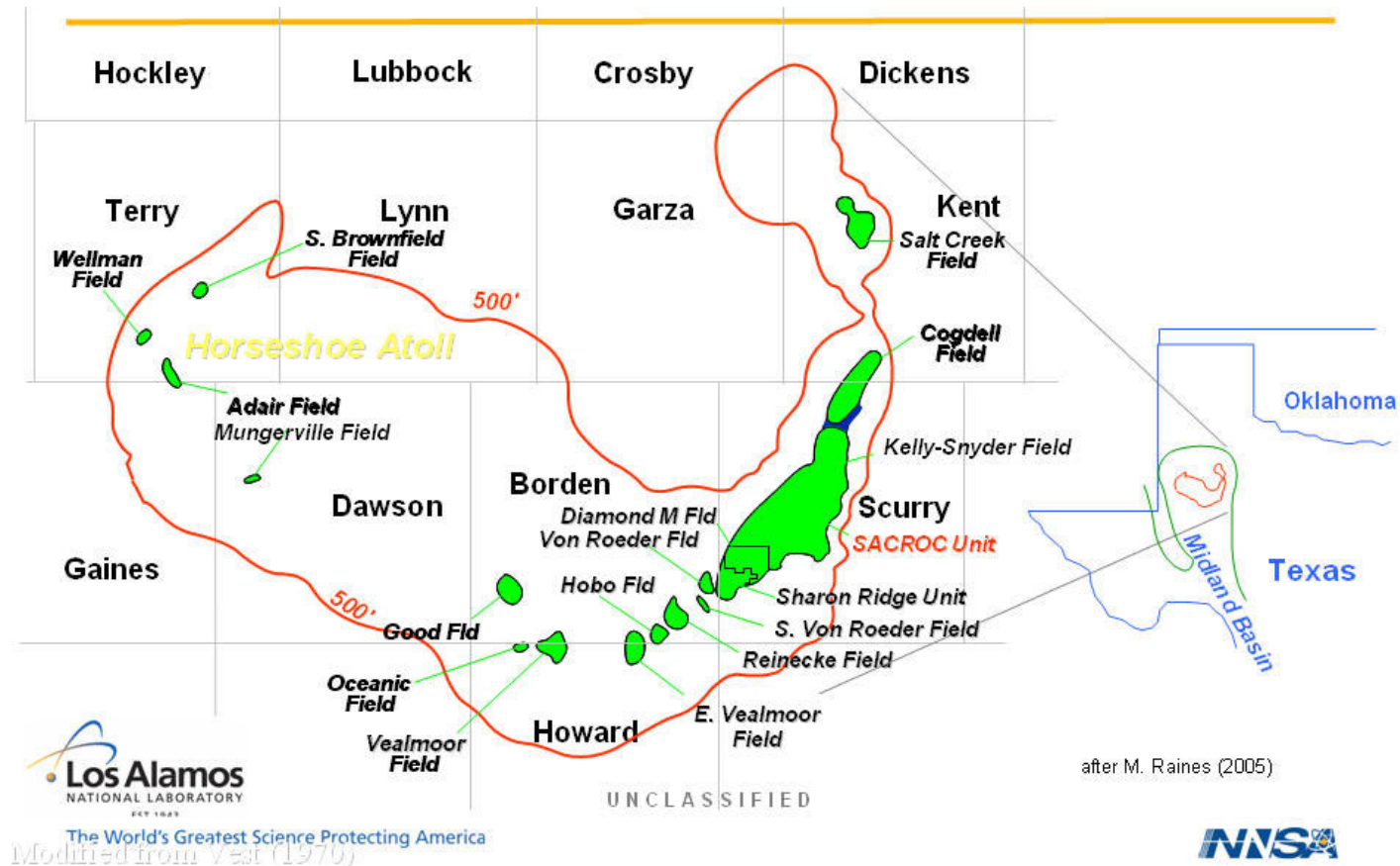
Presented by: Giday WoldeGabriel, Ph.D.
Los Alamos National Laboratory

Tel. 505-667-8749, 505-665-3285 (fax), E-Mail: wgiday@lanl.gov

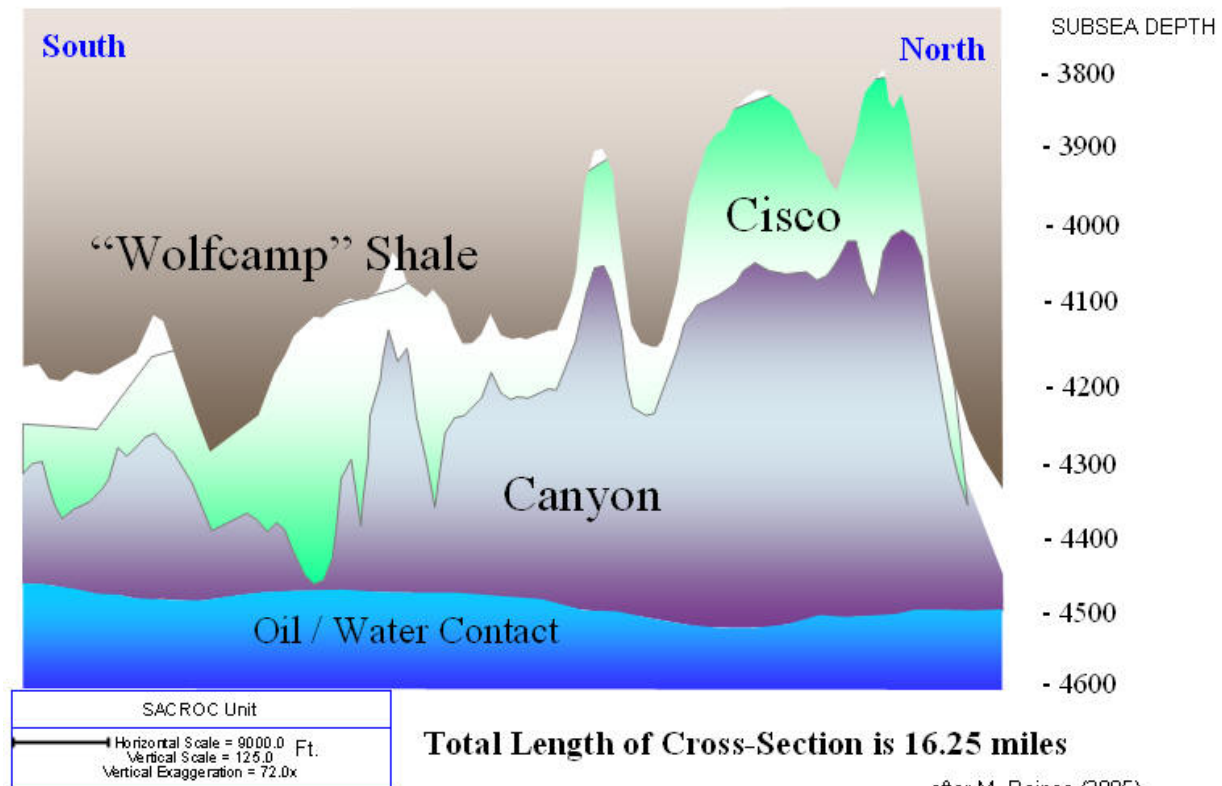
Rationale for Investigation:

- ❖ CO₂ has been injected for more than 3 decades into oil-producing carbonate reservoirs at SACROC unit in west Texas.
- ❖ Understanding the interaction between injected CO₂ and potential storage reservoirs is critical to predict the long-term fate of CO₂ sequestration.
- ❖ We characterized core samples from the shale cap rock and carbonate reservoir interface to investigate effects from the CO₂ injection near the contact zone and along fractures.

SACROC LOCATION MAP



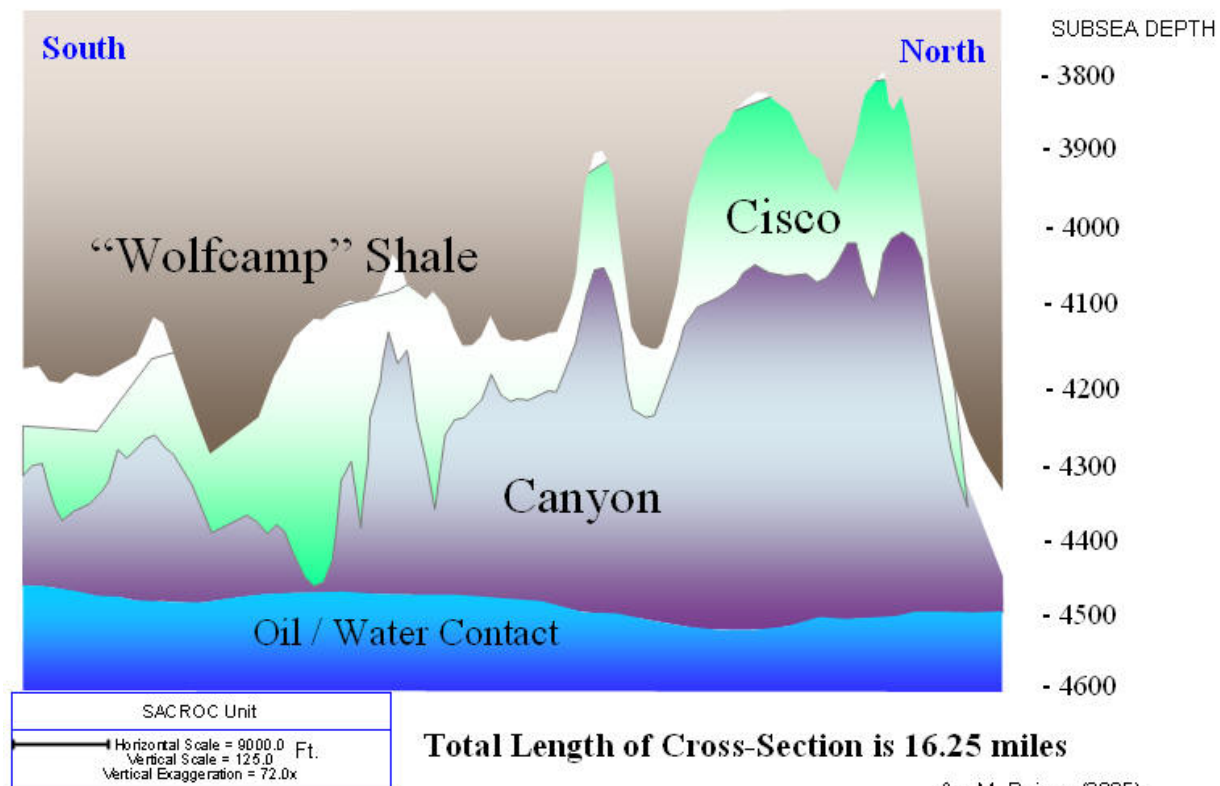
- ❖ SACROC unit is located along the southeastern segment of the 'Horseshoe Atoll' and consists of carbonate reef complex capped by clastic rocks.



- ❖ The subsurface geology consists of bedded Pennsylvanian bioclastic limestone of the Strawn, Canyon, and Cisco Groups capped by shale deposits of Permian Wolfcamp Series
- ❖ Most of the oil is produced from the Canyon and Cisco Formations (Vest, 1970).

Laboratory Analysis

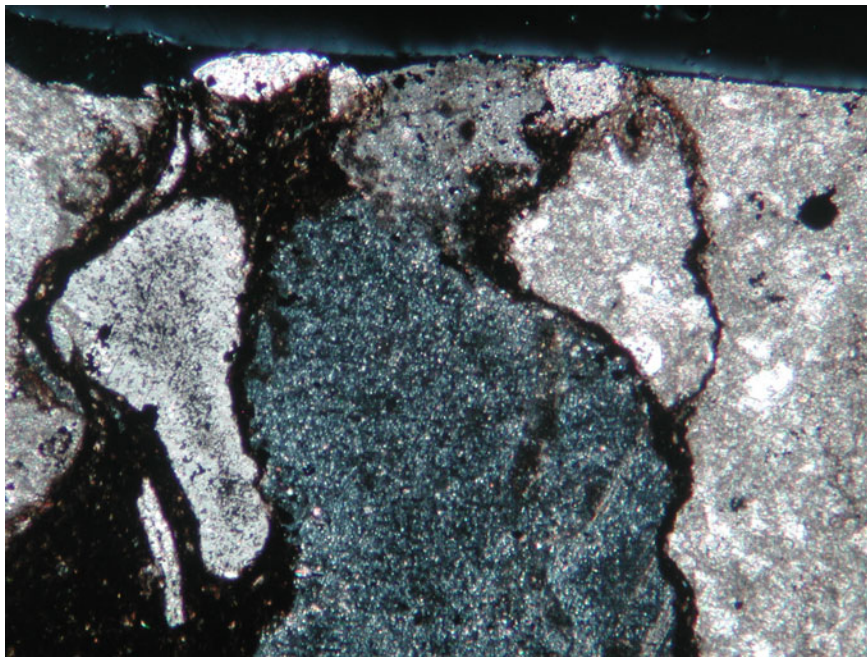
- ❖ Multiple samples were selected from the carbonate-shale contact zone in Wells 11-15 and 19-12 in the northern part of the SACROC unit.
- ❖ Petrographic, mineralogical, and chemical data were collected on these samples.



Petrographic Results

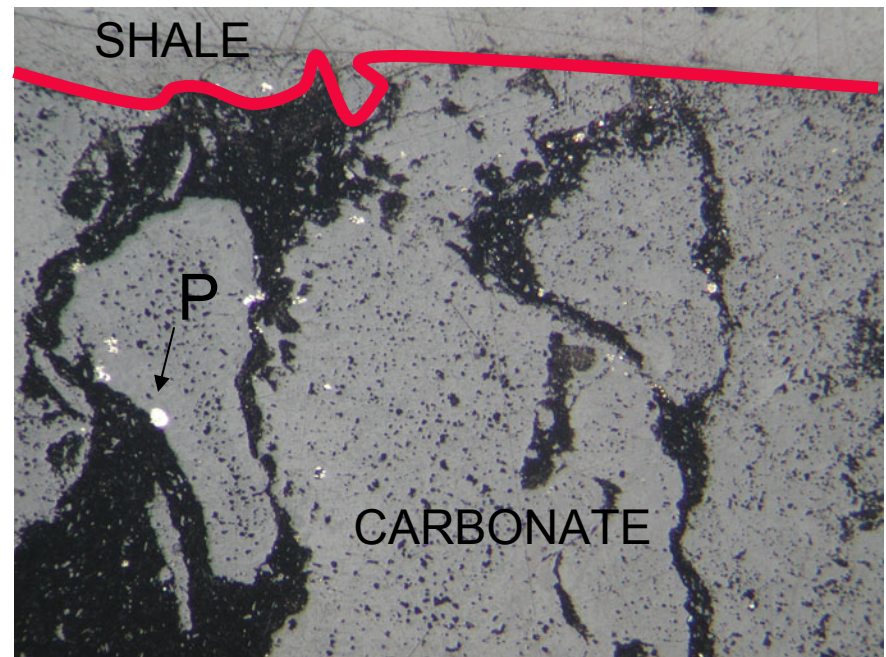
Optical Microscopy

- ❖ Carbonate reservoir below contact is altered and fractured.
- ❖ Fractured carbonate exhibits distinct textural features.
- ❖ Fractures filled with organic matter and clay
- ❖ Pyrite is closely associated with organic matter.



(Transmitted)

WELL 19-12 6418 ft



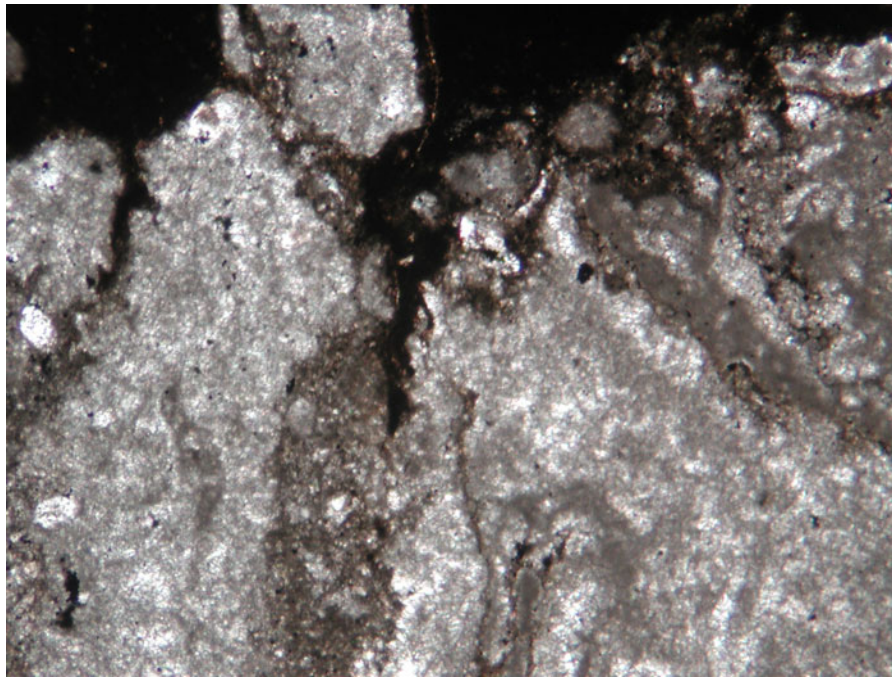
(reflected)

Petrographic Results

Optical Microscopy

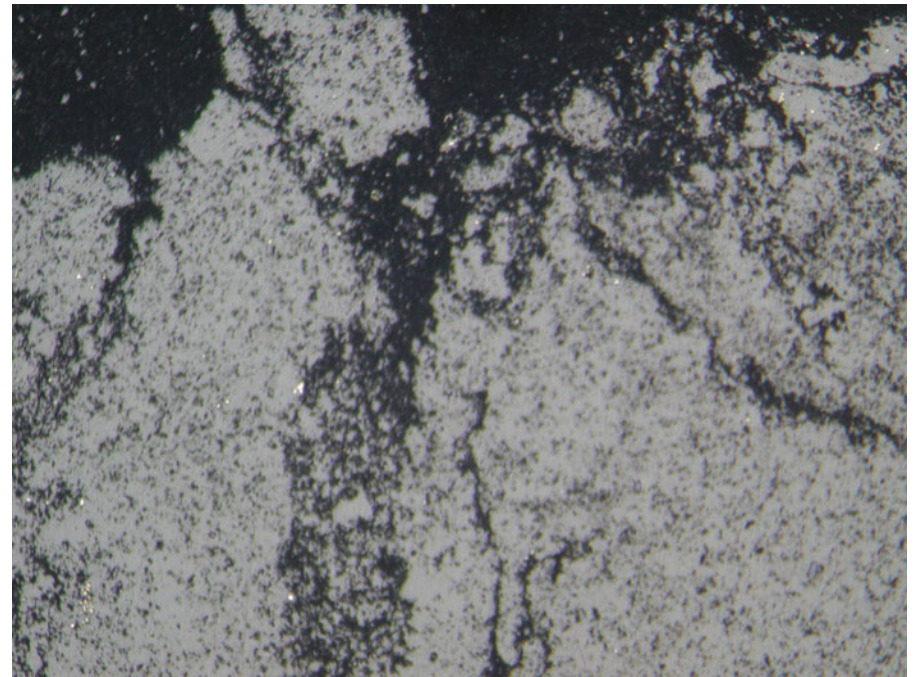
Carbonate-Shale Contact Zone

- ❖ Underlying carbonate is bleached close to fracture zone
- ❖ Organic matter, clay, and pyrite present in shale and fractures



(Transmitted Light)

Well 19-12 6418 ft

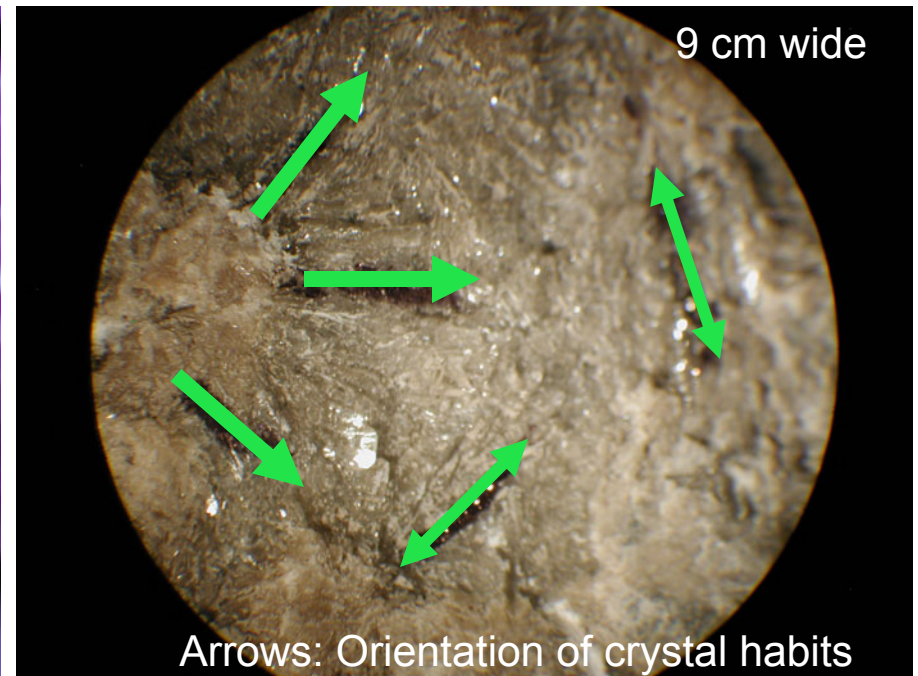
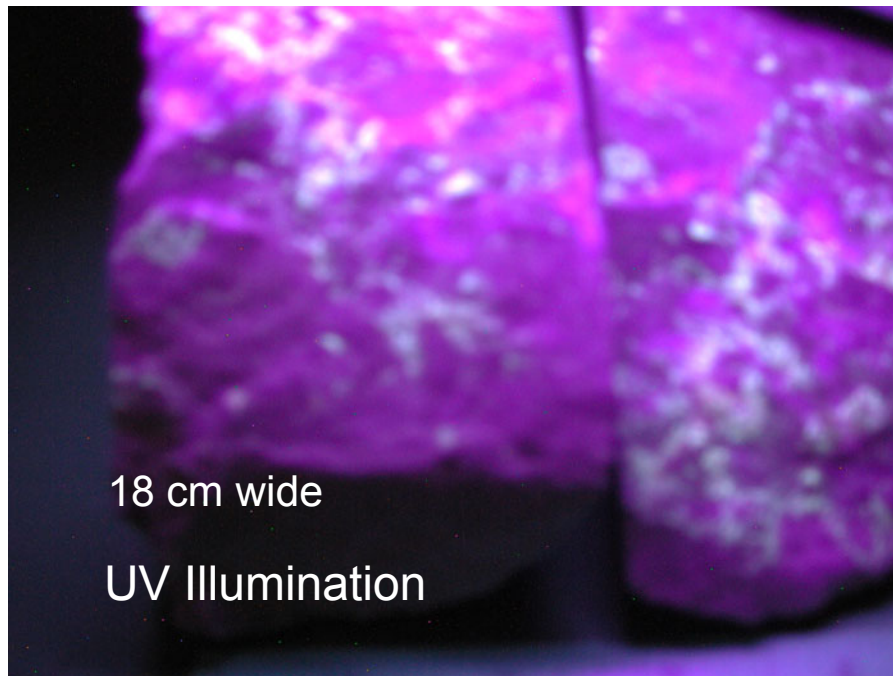


(Reflected Light)

Petrographic Results

Optical Microscopy

- ❖ Abundant secondary calcite crystallized along vertical fractures less than 20 cm below contact zone.
- ❖ Multiple generation of calcite noted.
- ❖ Veins, veinlets, vugs of calcite noted in carbonate.
- ❖ In Well 11-15, calcite has similar $\delta^{13}\text{C}$ (2.46-2.52‰) as carbonate but lighter $\delta^{18}\text{O}$ (24.59-25.20‰).

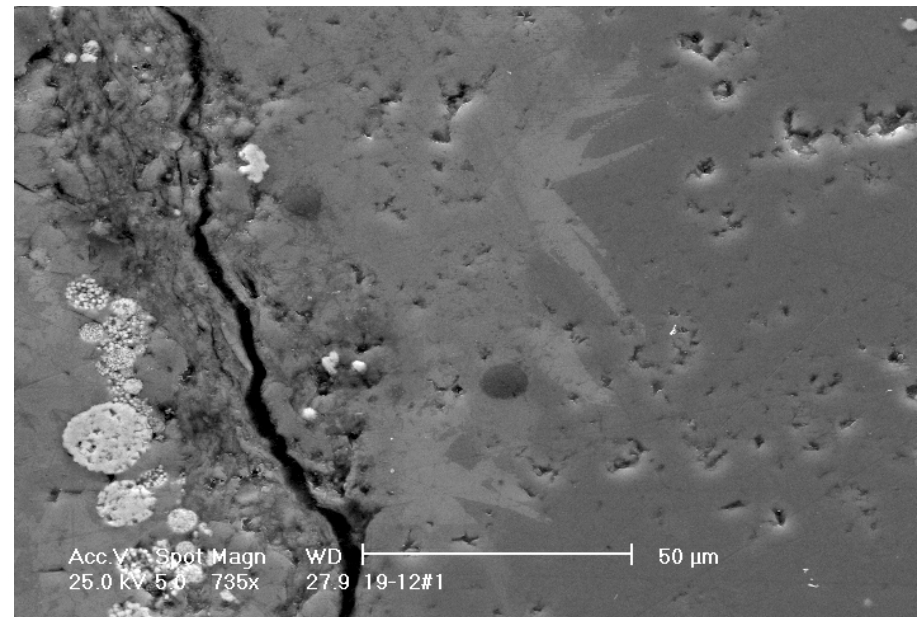
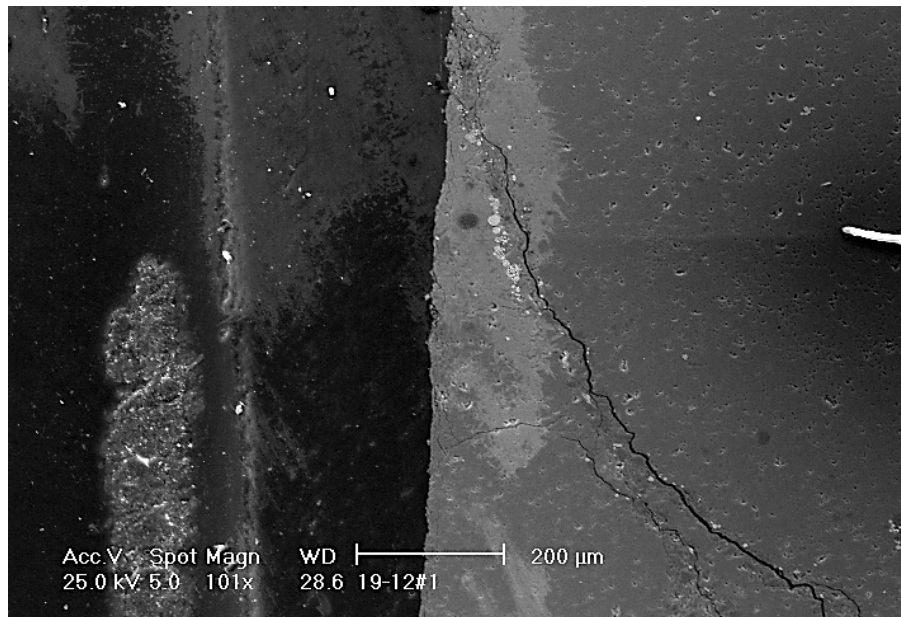


Well 11-15 6366-6366.5

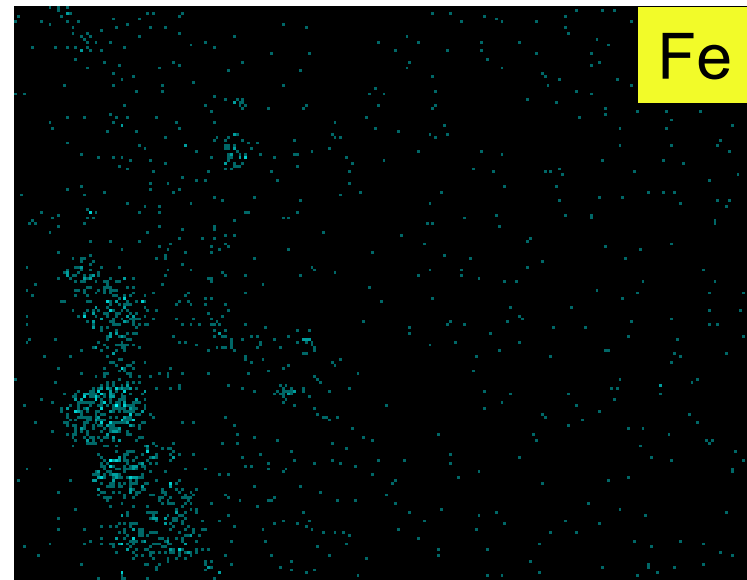
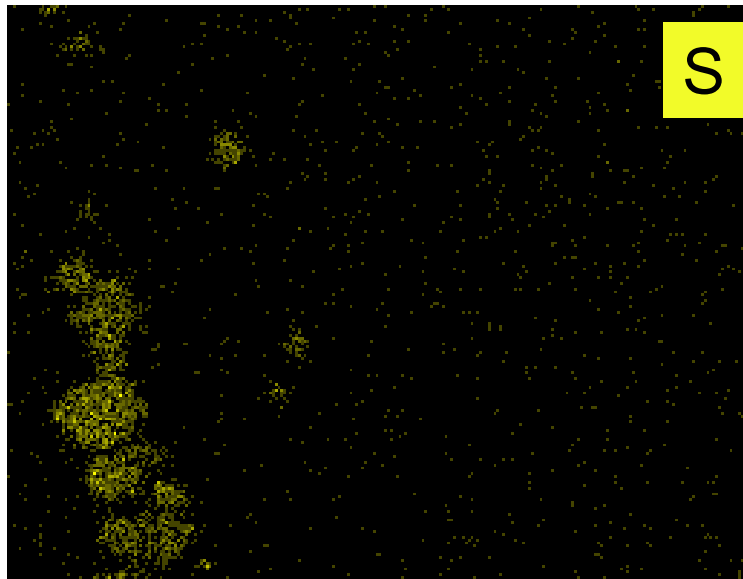
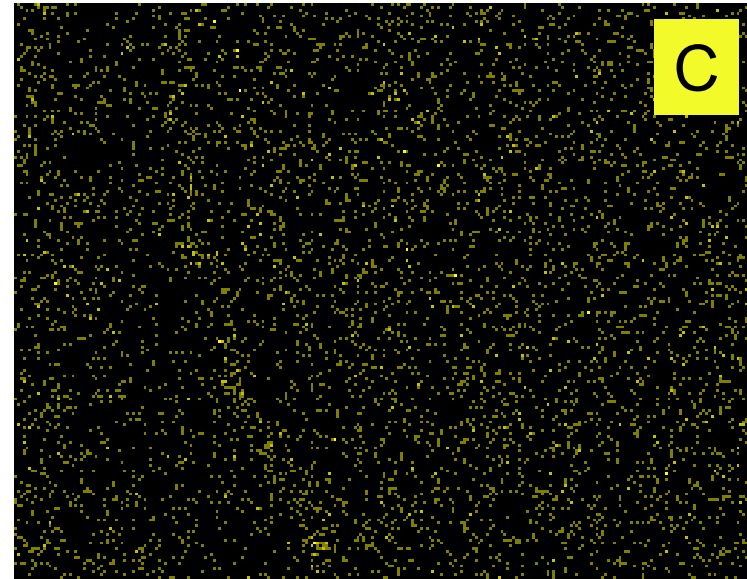
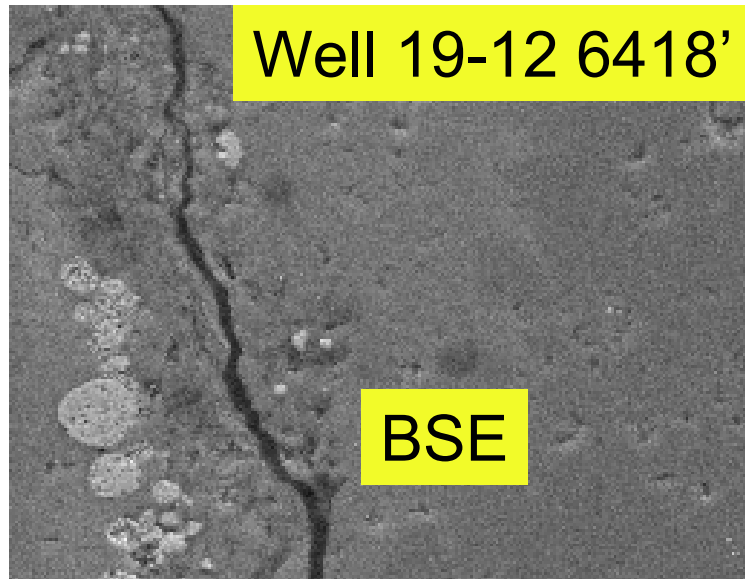
Petrographic Results

Scanning Electron Microscopy

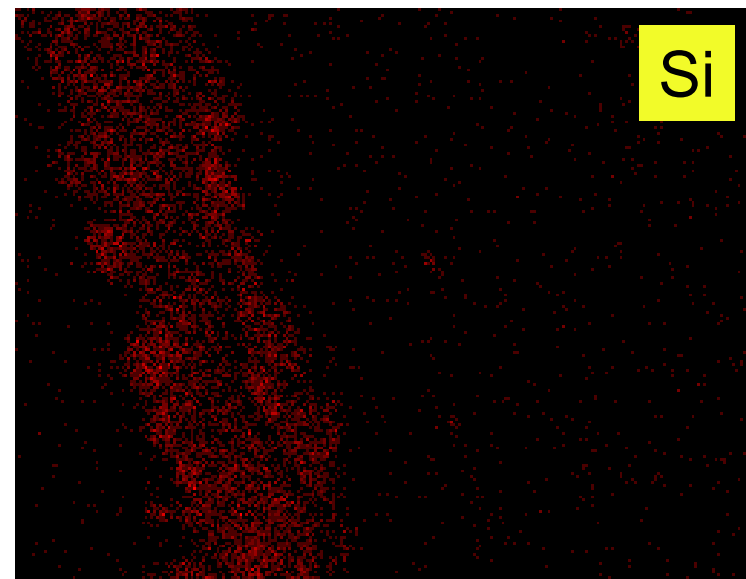
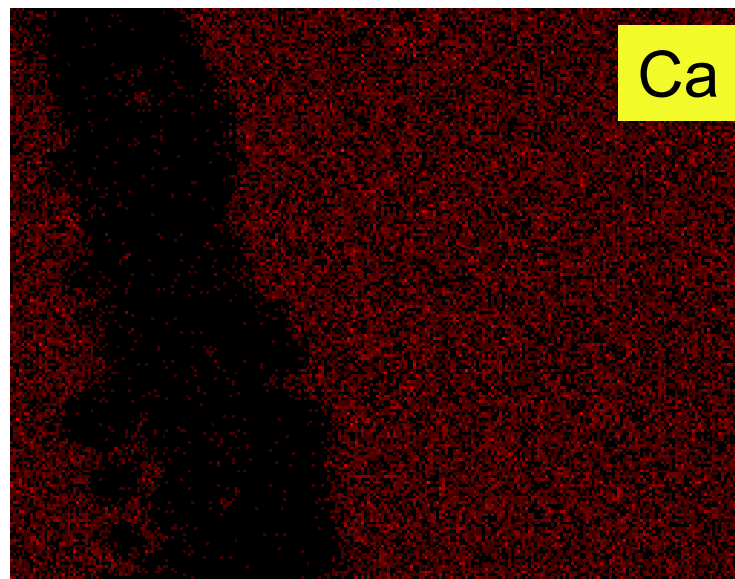
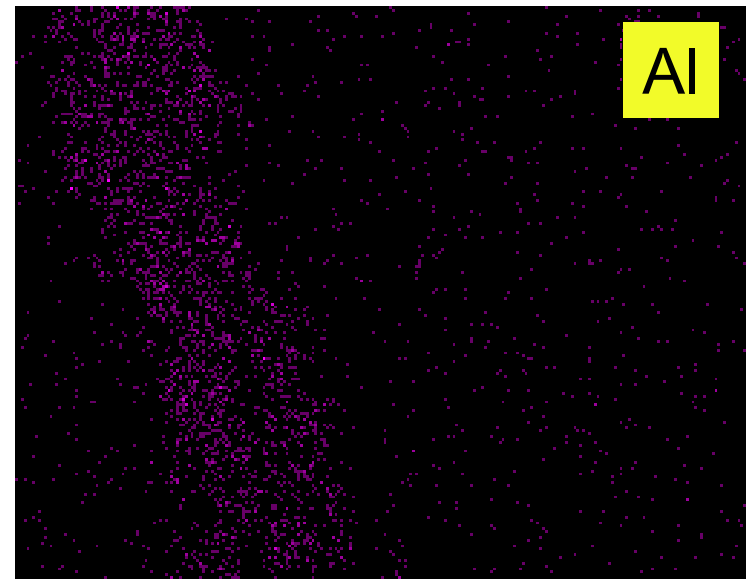
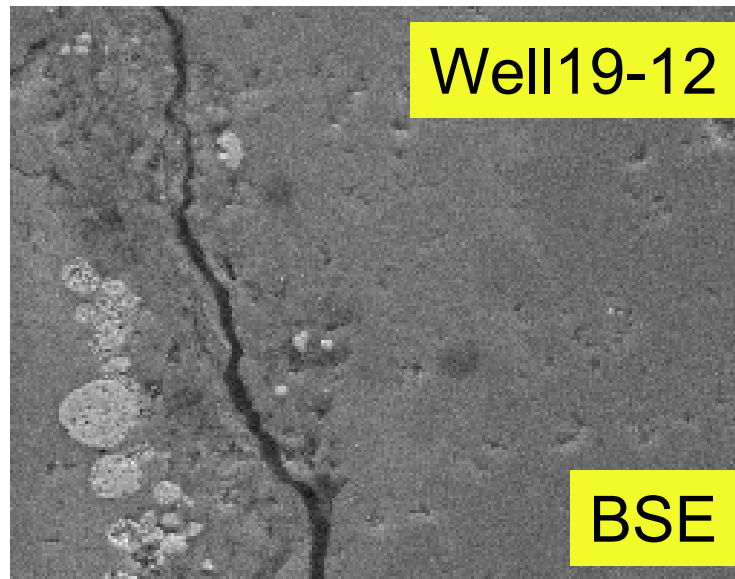
- ❖ Fractures with organic matter disappear within 20 cm from contact.
- ❖ Organic matter migrated into fractured carbonate during diagenesis from shale cap rock.
- ❖ Pyrite aggregates and clays (illite) closely associated with organic matter



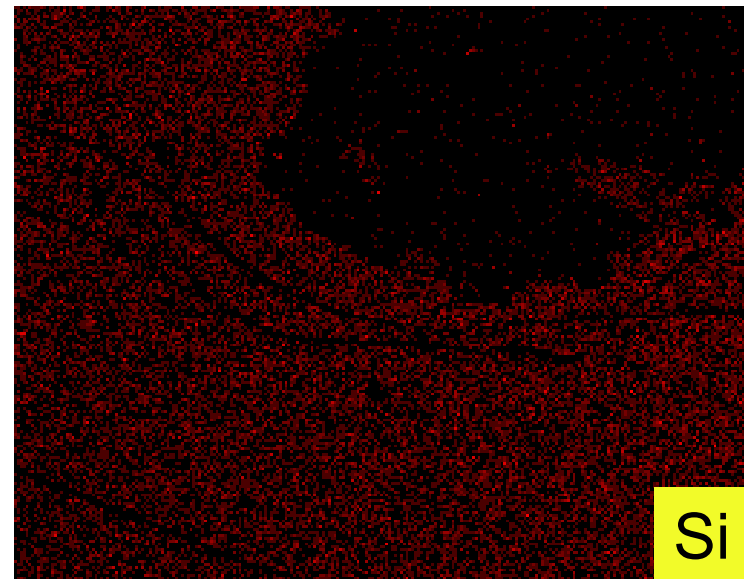
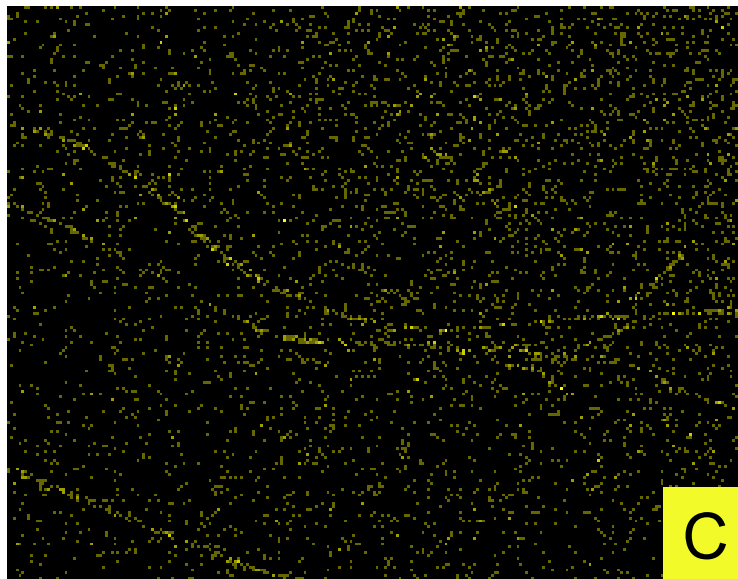
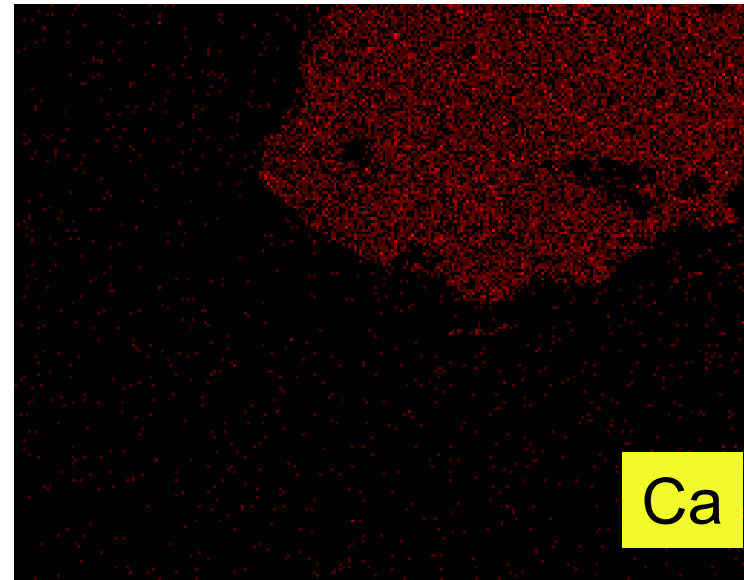
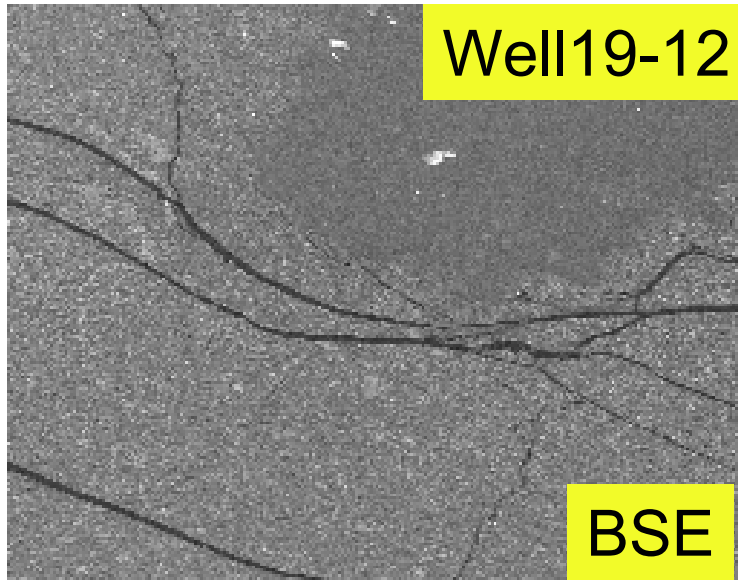
SEM Elemental Map of samples from carbonate-shale contact (Distribution of organic matter and pyrite)



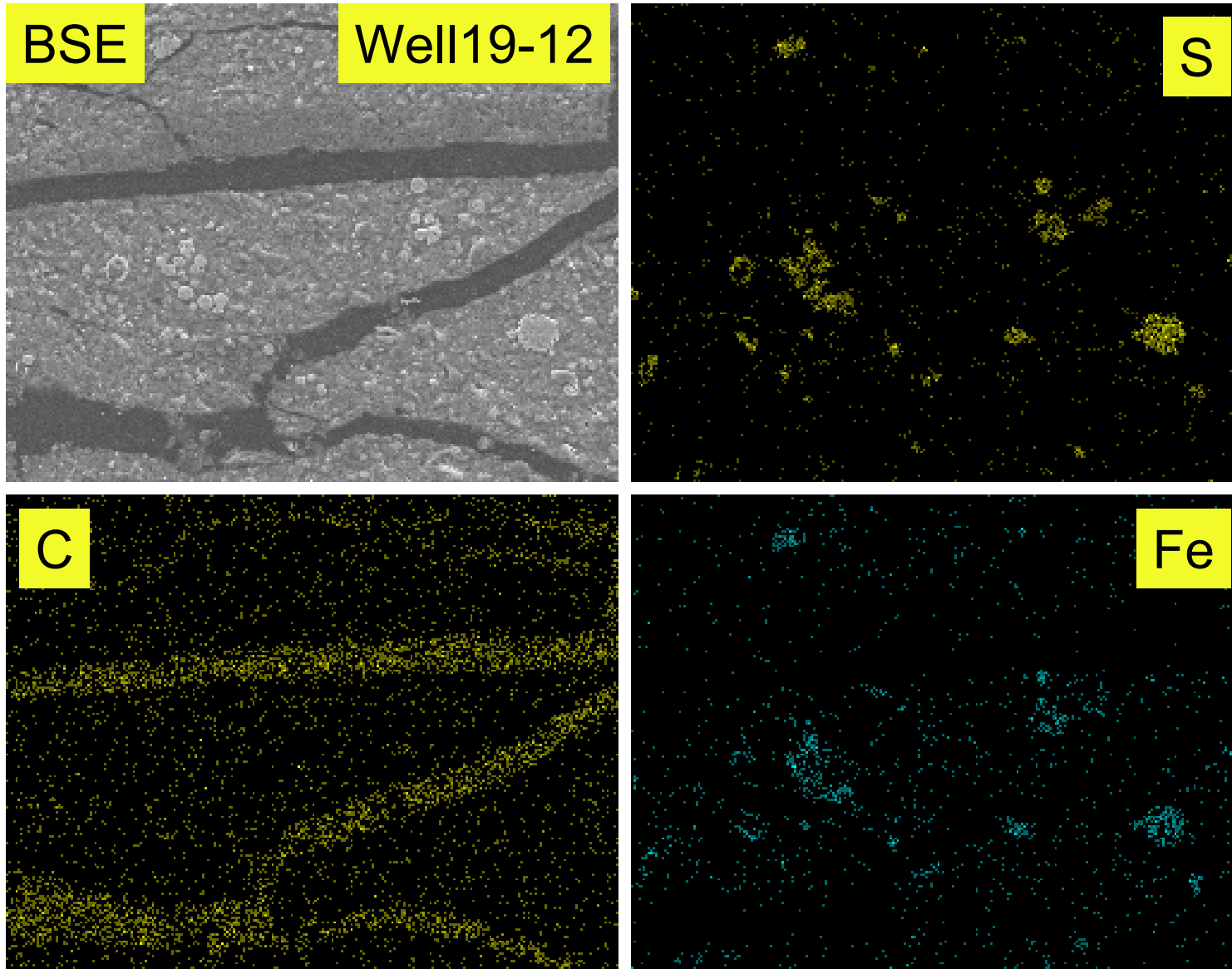
SEM Elemental Map of samples from carbonate-shale contact (Distribution of carbonate and clay)



SEM Elemental Map of samples from carbonate-shale contact (Distribution of carbonate, clay, and organic matter)

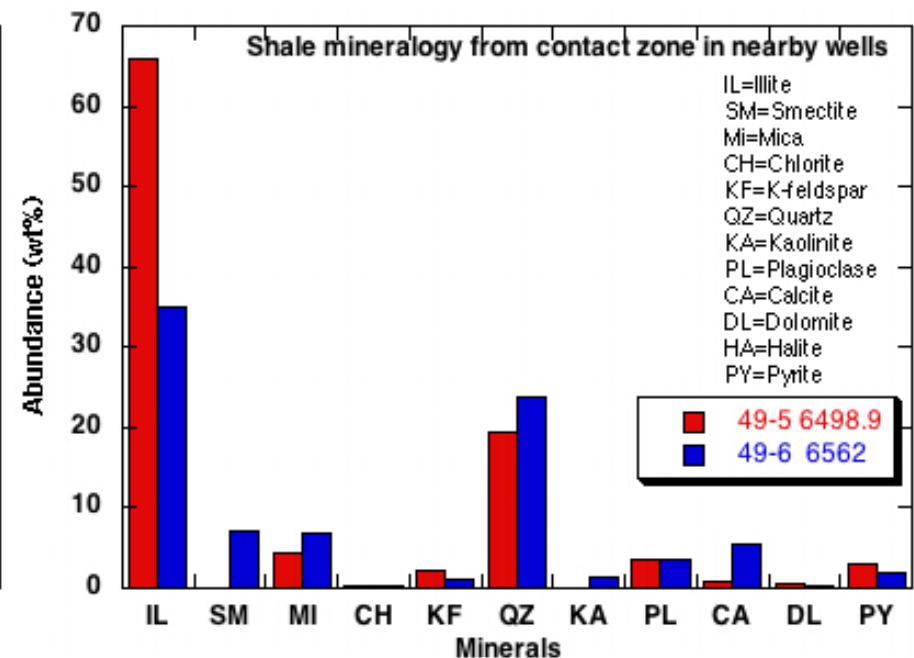
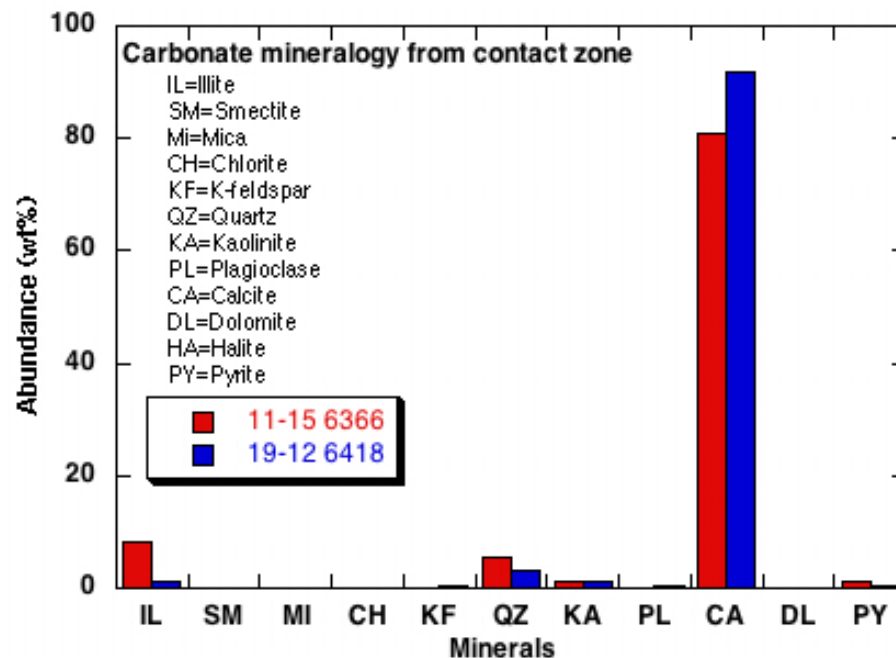


SEM Elemental Map of samples from carbonate-shale contact (Veins organic matter and pyrite in shale).



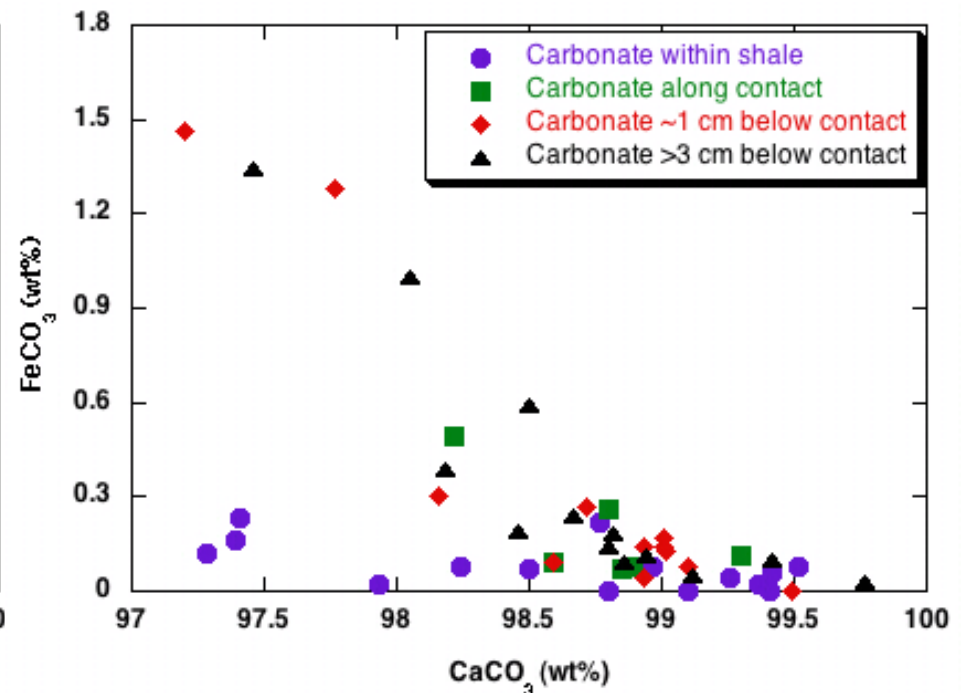
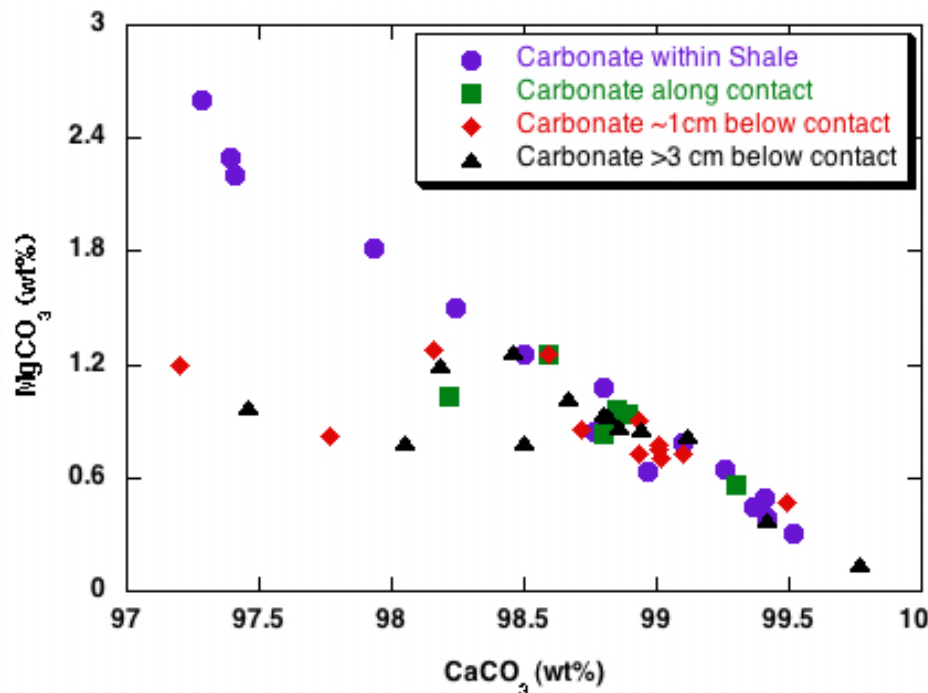
Carbonate and Shale Mineralogy

- ❖ Samples from carbonate reservoir near contact zone are dominated by calcite.
- ❖ Illite and quartz are abundant in shale samples collected at the contact zone in nearby wells.
- ❖ Variations in compositions noted in samples.
- ❖ Totals for compositions of shale (<95 wt%) and carbonate (~97 wt%) samples are low due to organic matter and other amorphous components.



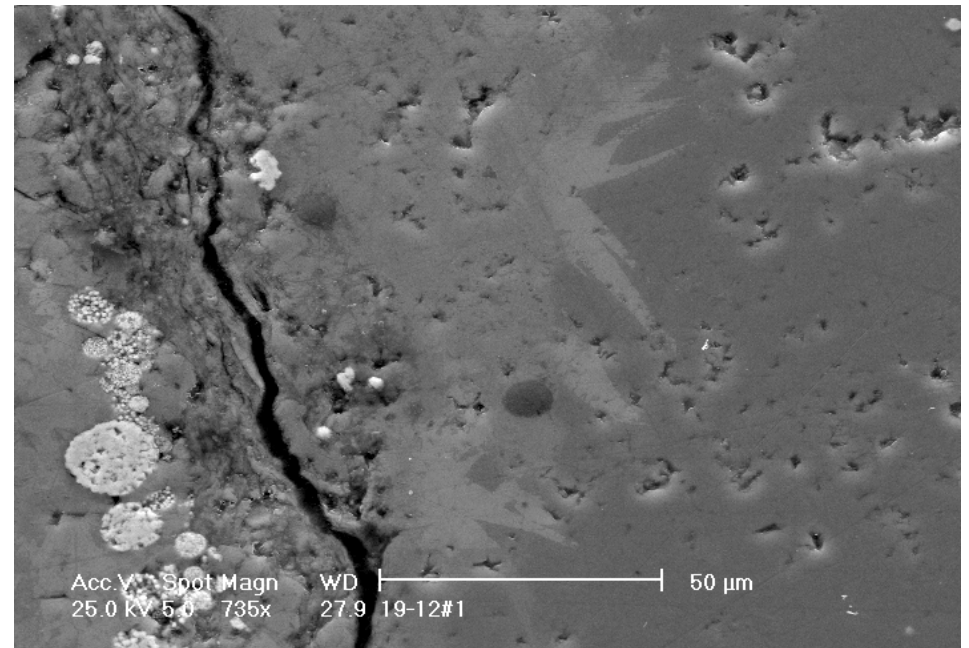
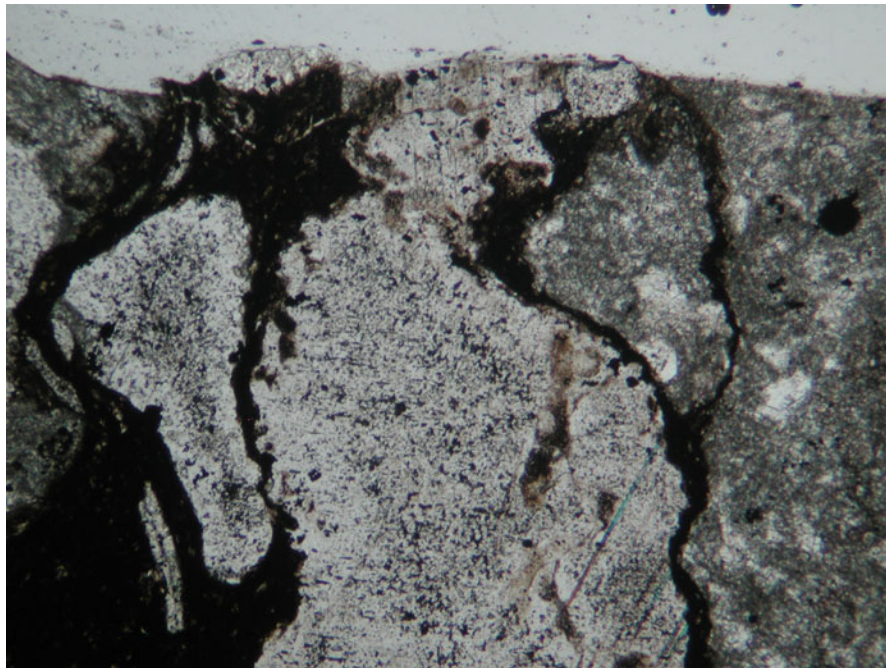
Carbonate Composition from Electron Microprobe Analysis

- ❖ Carbonate clasts within shale, along shale-carbonate, and below contact dominated by calcite with minor magnesite and siderite.
- ❖ Magnesite content greater in carbonate clasts within shale cap rock.
- ❖ Siderite content greater in carbonate rocks below contact.



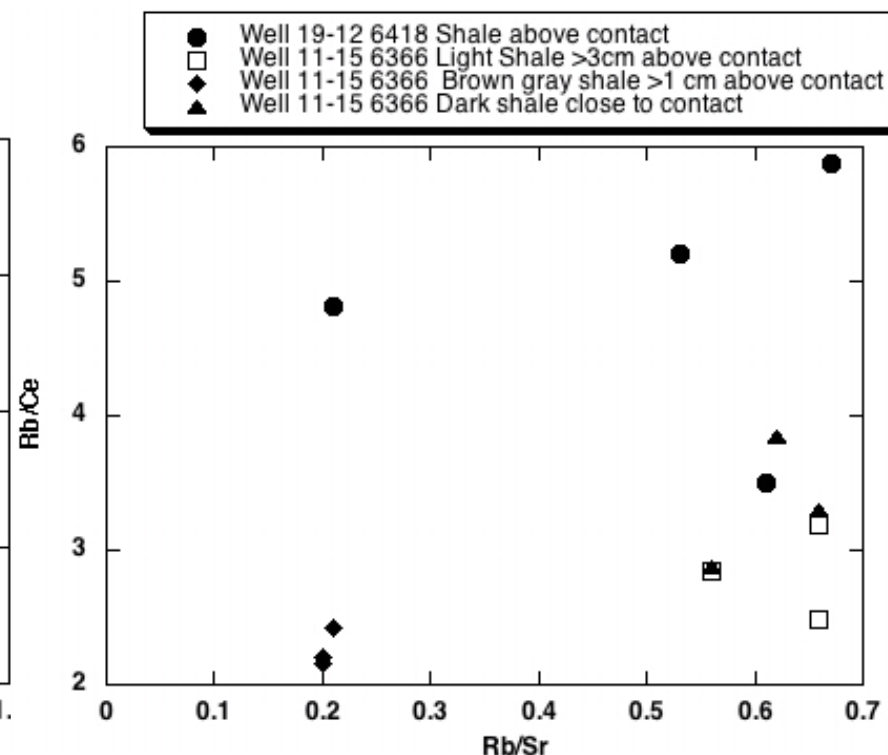
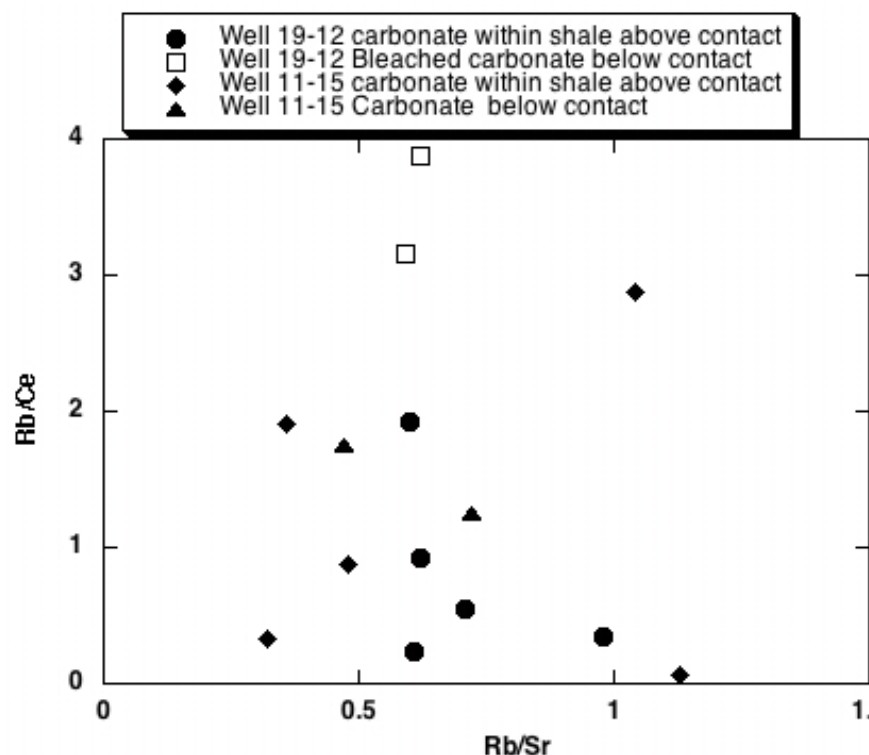
Carbonate Composition

- ❖ Calcite composition of carbonate clasts above and below contact exhibits minor variation (95-99 wt%).
- ❖ Variation probably related to dissolution.
- ❖ Bleached zones that are mostly developed adjacent to fractures filled with organic matter and clays and along contact with shale yielded lower calcite content.
- ❖ Alteration appears related to diagenesis.



Preliminary LA-ICP-MS Analysis Carbonate and Shale Composition

- ❖ Variations noted in trace element ratios within samples from shale caprock and carbonate reservoir.
- ❖ However, some carbonate and shale samples contain similar Rb/Ce and Rb/Sr ratios.



SUMMARY AND CONCLUSION

- ❖ Carbonate along contact zone with shale cap rock is strongly fractured and partially altered.**
- ❖ Most fractures are vertical and terminate at the carbonate-shale contact.**
- ❖ Fractures are filled with veins of organic matter and clay minerals that originated in the overlying shale.**
- ❖ Alteration halo and bleached zones developed adjacent to fractures.**

SUMMARY AND CONCLUSION

- ❖ Preliminary stable isotope data from secondary calcite and carbonate host rock indicate similar composition in $\delta^{13}\text{C}$ (2.46-2.52‰) but slightly lighter $\delta^{18}\text{O}$ (24.59-25.20‰) compared with >27‰.**
- ❖ Difference in $\delta^{18}\text{O}$ attributed to local dissolution of carbonate and crystallization of calcite during diagenesis.**
- ❖ Petrographic, mineralogical, and chemical results from the reservoir-cap rock contact zone in Wells 19-12 and 11-15 show no recent alteration related to CO_2 injection.**
- ❖ ADDITIONAL ANALYSIS WILL BE CONDUCTED ON CORE SAMPLES DRILLED PRIOR TO CO_2 INJECTION AT SACROC UNIT TO COMPARE RESULTS.**